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ABSTRACT

The purpose of this manual is to consolidate into a single document all the maintenance and operational steps that, when implemented, will result in the lowest energy use consistent with school educational programs. The manual describes procedures for keeping the building and its equipment well maintained and efficiently run, establishing realistic standards for the energy requirements for the various activities in the school and adjusting the equipment to provide no more than these standards, and scheduling so that electricity and fuel are used only where and when needed. An appendix at the end of the manual contains supplementary information, including a chart for troubleshooting the heating plant, instructions for the evaluation and modification of existing systems, schedules, tables and record blanks to be used in connection with the various procedures, and some other background information. (Author/MLF)

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low energy
utilization school

energy conservation operation manual

phase 2: report

board of education
city of new york

sponsored by the
national science foundation
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Opinions, findings, inclusions, and recommendations expressed in this report are those of the author and do not necessarily reflect the views of the National Science Foundation.

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Note: The Manual of Procedures for School Custodians and School Custodian Engineers prepared by the Bureau of Plant Operation, Division of School Buildings, of the New York City Board of Education is referred to throughout this manual as basic reference material.

preface

The purpose of this manual is to consolidate into a single document all of the maintenance and operational steps which, when implemented, will result in the lowest energy use consistent with the school's educational program.

It incorporates information from standard operating instructions already issued in separate documents and memoranda by the Bureau of Plant Operation, its Fuel Management Section, and other sections of the Board of Education's Division of School Buildings, as well as instructions based on conclusions reached in the first phase of this study of energy efficiency in schools, done for the Board of Education with funds supplied by the National Science Foundation. Further recommendations and guidelines, based on other material published recently in response to the energy crisis are also included.

All material contained in the manual has been approved and authorized by the Board of Education through the Division of School Buildings, the Bureau of Facilities Planning and Design, and the Bureau of Plant Operation.

The manual is organized according to the following categories. When implemented, the procedures described will provide the basis for increased efficiency in the use of energy.

plant operation

- Keeping the building and its equipment well maintained and efficiently run.

standards

- Establishing realistic standards for the energy requirements for the various activities in the school and adjusting the equipment to provide no more than these standards.

scheduling

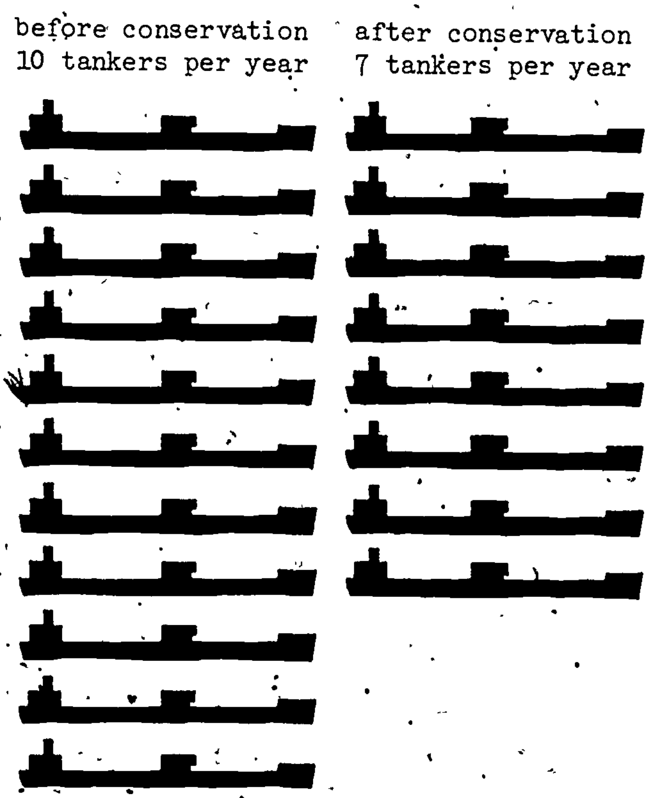
- Using energy - electricity and fuel - only where and when it is needed.

The discussion mainly concerns procedures which are the custodian's responsibility, but also includes some which are not his responsibility and are generally performed by maintenance personnel. These non-custodial functions have been included to familiarize the custodian with all operations. He should be alert for all problems and potential improvements and should contact his Borough Supervisor's Office of the Bureau of Plant Operation for assistance when needed. The Borough Supervisor will instruct the Bureau of Maintenance (or outside contractors, if required) to do the necessary work.

An Appendix at the end of the manual (organized according to the same categories as the body of the manual) contains supplementary information including a chart for troubleshooting the heating plant, instructions for the evaluation and modification of existing systems, schedules, tables and record blanks to be used in connection with the various procedures, and some other background information. Where appropriate, blank forms are to be photocopied and filled in as part of the process of revising the systems to improve the operating efficiency of the school plant. Written records of procedures and data should be kept whenever possible and should be available at all times. Copies of schedule tables, when completed, should be posted at appropriate control centers to facilitate implementation of energy saving use. Availability of such information should never be dependent on the presence or memory of any one person.

Any suggestions regarding procedures, equipment modifications, or operational improvements that would be helpful to other custodial staffs should be noted down and sent to the Bureau of Plant Operations.

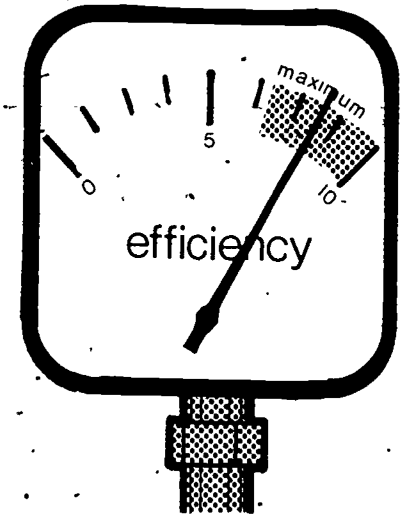
The importance of efficient energy use has been stressed enough to make further explanation unnecessary.



3 less tankers of oil are used with energy conservation

plant operation

This section is comprised of a set of guidelines for maintenance and operating procedures for energy efficiency in the plant.



The goals for greater efficiency are:

1. GET THE MOST HEAT OUT OF EACH GALLON OF OIL BURNED (combustion efficiency at the burner).

2. CONVERT THE MAXIMUM AMOUNT OF THAT HEAT INTO STEAM IN THE BOILER (keep the tubes clean to permit transfer of the heat from the combustion gases into the water which becomes steam - control the rate of flow of the gases to allow the maximum absorption by the water of the heat).

3. GET THE MOST HEAT OUT OF THE STEAM AND INTO THE AREAS WHERE IT IS NEEDED (keep all steam traps in good working order).

4. KEEP THE HEAT IN THE BUILDING (do not overheat the rooms; do not dump the heated air out of the building by excessive operation of the exhaust systems).

These guidelines do not constitute a complete list of maintenance and operating procedures and include only those operations which relate specifically to energy efficiency. They are organized according to the frequency required and should be incorporated in the list of normal routines (if they have not already become standard). Very little extra time is required, and if performed regularly, these procedures can contribute greatly to curbing excessive use of fuel.

HEATING SYSTEM

TROUBLESHOOTING

Recognition of problems in the system is crucial to the operation of any mechanical plant and can contribute significantly to its energy efficiency. TABLE 1, on page a/po - 43 in the Appendix, relates symptoms which may be evident (such as oil leaks, carbon build-up, noises, irregularities in the appearance of the flame, etc.) to problems, and should serve as a guide to remedies to correct these problems.

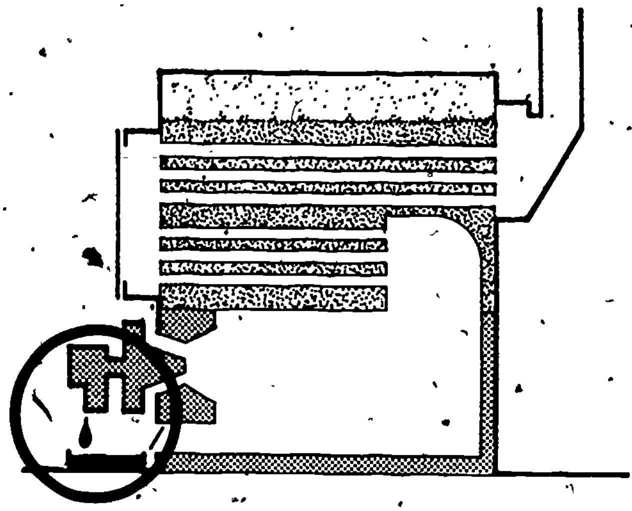
In performing the routine operations, be alert for any of the symptoms listed in the table and make the adjustments indicated wherever possible. If there are problems which require outside assistance, list them and submit the list to the Borough Supervisor's Office of the Bureau of Plant Operation.

DAILY MAINTENANCE AND OPERATION

In the description of routine operations which follow, "check" means to look for. Whenever a problem is evident, consult TABLE 1 for interpretations.

every morning before startup

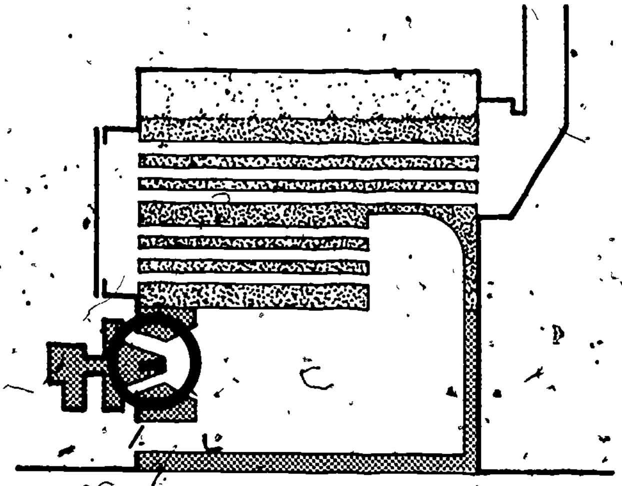
1. CHECK FOR SIGNS OF OIL LEAKAGE under and around the burner and pump. If you find leaks, determine whether they are lubricating oil (light brown) or fuel oil (almost black). If the leak is lubricating oil, make sure that reservoir has sufficient oil to prevent damage to the equipment. Check this level frequently until the leak has been corrected. If the leak is fuel oil, check whether the oil burner strainer housing is firmly mounted and all fittings are tight. If the leak cannot be corrected, contact Borough Supervisor's Office of the Bureau of Plant Operations to have the unit repaired.



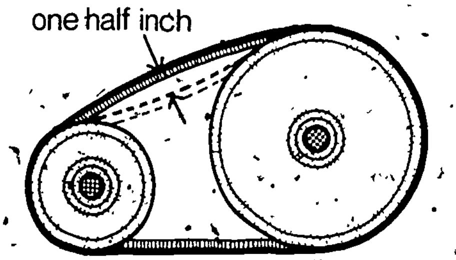
Note: Use a metal pan to catch oil drippings under the burner rather than sand, sawdust or sweeping compound. This makes it easier to determine whether leaks are lubricating or fuel oil, and it avoids the risk of loose materials being sucked into the primary air intake.

2. OPEN THE BURNER AND SCAN COMBUSTION CHAMBER to check for carbon build-up (black dirt or black, caked deposits).

3. WIPE THE ATOMIZER CUP with a clean rag. Check for dirt and carbon. This is a double check since the cup should have been wiped the night before. However, with the burner open, it will take only a few seconds and is worth doing.

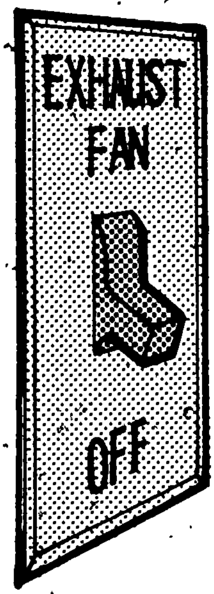


4. CHECK THE BURNER BELT. It should have some play for smooth operation but should not exceed a half inch.

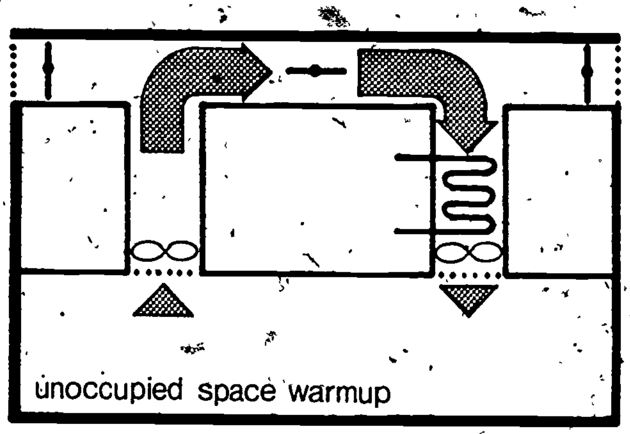


5. MAKE ALL NORMAL SAFETY AND OPERATING CHECKS.

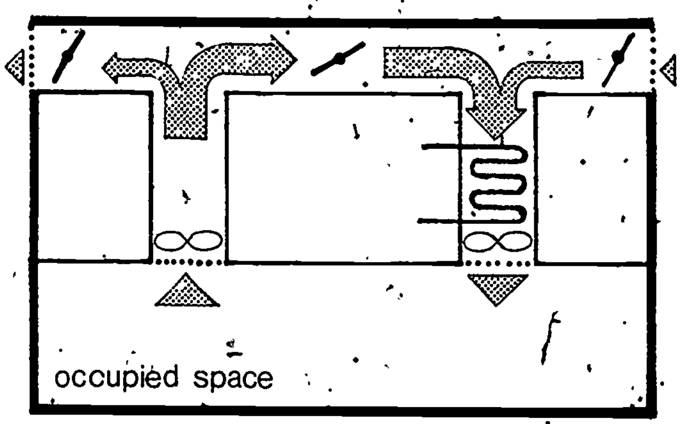
Note: Do not turn on exhaust fans until the areas they serve are actually occupied.



Do not turn on indirect heating systems until actually required. If the gymnasium is not going to be used until 11 a.m., it is not necessary to have it pre-



heated at 8:45 a.m. If possible, keep indirect heating systems on 100 percent recirculation during warm-up and minimum out-side air intake when occupied.



6. <u>TURN THE BURNER ON</u>. As the burner starts, be alert for unusual noises, vibrations or other signs of trouble. If these occur, shut the burner down until the problem is located. This may prevent serious damage.

<u>Note</u>: Use the fewest number of boilers necessary to maintain the required steam pressure. If the plant contains boilers of different capacity, fire the smaller one whenever it will carry the load.

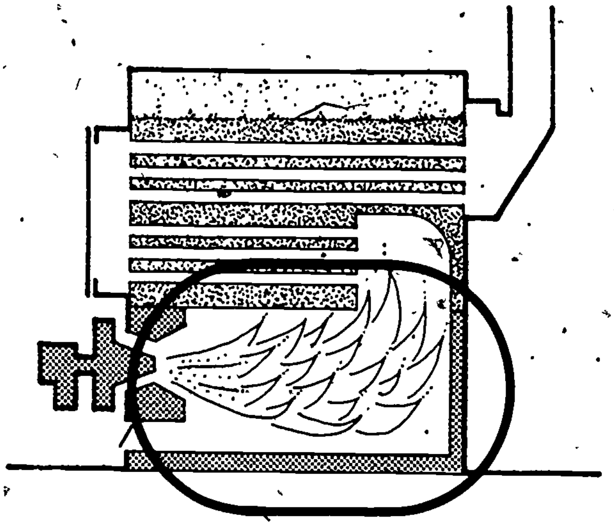
every morning after the boiler is hot

1. CHECK THE FLAME and refer to TABLE 1 for any irregularities. The flame should:

- be a golden orange color
- fill the combustion chamber at high firing rate.

The flame should not:

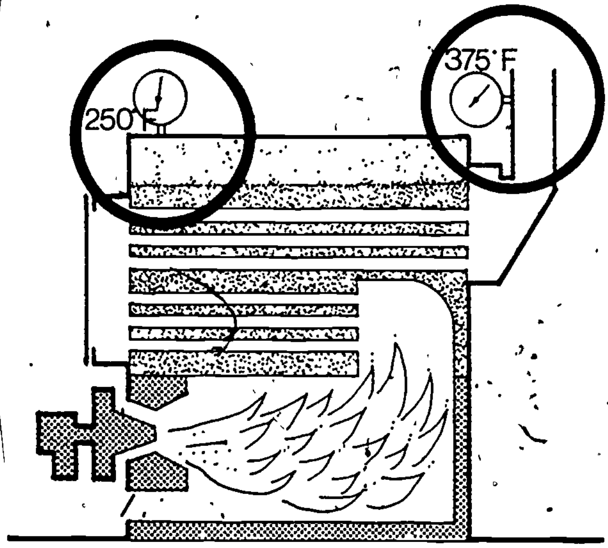
- be pale yellow
- contain sparks
- produce smoke in combustion
- strike the sides, top or bottom of combusion chamber
- bounce off rear wall of combustion chamber



Note: The flame may "lap" against rear wall of combusion chamber; however, it should not strike it with any force.

2. CHECK THE STACK TEMPERATURE.

Note: The higher the temperature, the more heat is going up the chimney and the less is being absorbed by the boiler. Stack temperature should be about 125° F. above boiler water temperature.



periodically during the day

1. CHECK CONDENSATE RETURN TEMPERATURE. Rising temperature at the return side of the trap indicates one or more leaking steam traps in the system.

2. CHECK THE FLAME.

3. CHECK THE STACK TEMPERATURE. (See above.)

4. CHECK THE DRAFT GAUGE.

Note: The draft should range between 0.5" and 0.8" depending on the unit. Consult the burner manufacturer's specifications for particular units.

5. CHECK THE OIL TEMPERATURE IN THE TANK.

Note: The temperature should be 110° - 120° F. for No. 6 oil and should never exceed the flash point. Check for flash point of each batch on oil delivery slip.

6. CHECK OIL SUPPLY TEMPERATURE AT THE BURNER.

Note: The required temperature varies with the oil content; lower sulphur content in No. 6 oil will permit lower oil temperature. Find the optimum temperature for each batch and check periodically to maintain it.

7. BE ALERT FOR UNUSUAL NOISES. See TABLE 1 for interpretations.

shutdown time

1. SHUT THE BURNER DOWN as early in the day as possible.

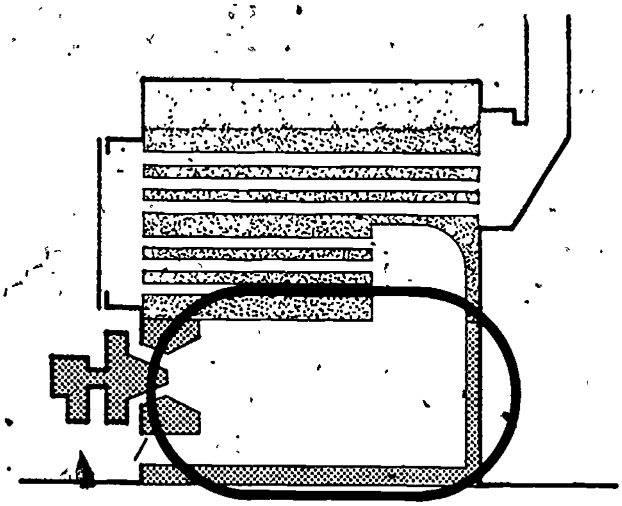
Note: The heat from people and lights will keep a building warm for some time. The exact length of coasting time will vary considerably depending on the building skin, the outside temperature and the amount of air being introduced by the ventilation system, and must be worked out for each building by experimentation. (See section on Scheduling.)

2. SHUT DOWN ALL SYSTEMS WHICH BRING IN OUTSIDE AIR as early as possible. These include kitchen and lab hoods and indirect air systems which are not on 100 percent recirculation:

after shutdown

When the combustion chamber has had a chance to cool (approximately 2 hours), open the burner. (Opening the burner when the combustion chamber is hot will cause a sudden rush of cold air which may damage the refractory.)

1. CHECK THE COMBUSTION CHAMBER for carbon.

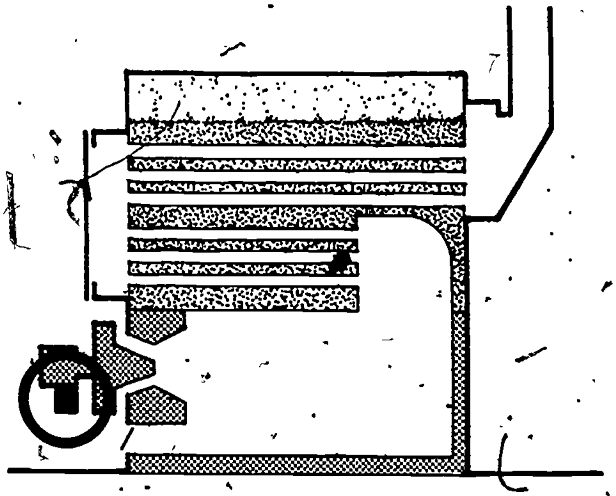


2. WIPE THE CUP with a clean rag. Check it for carbon, dents, and other irregularities which may cause vibration or uneven oil distribution. Do not remove the cup if the system is operating properly. Removal may result in damage or incorrect remounting of the cup.

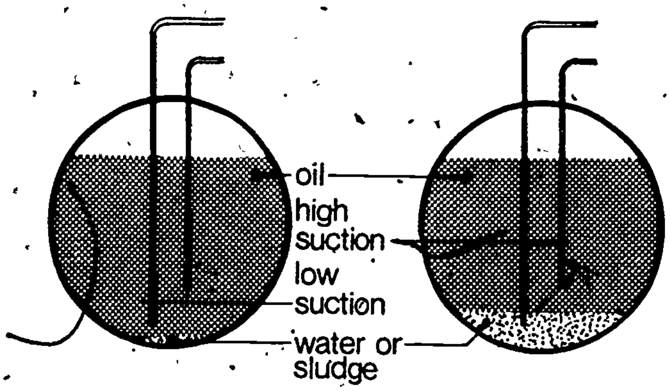
WEEKLY MAINTENANCE

1. CHECK AND CLEAN THE FUEL OIL STRAINERS. A seriously clogged strainer will cause poor oil delivery and as a result, a poor flame which will show up in daily inspections. If the amounts of sludge in the strainer increase,

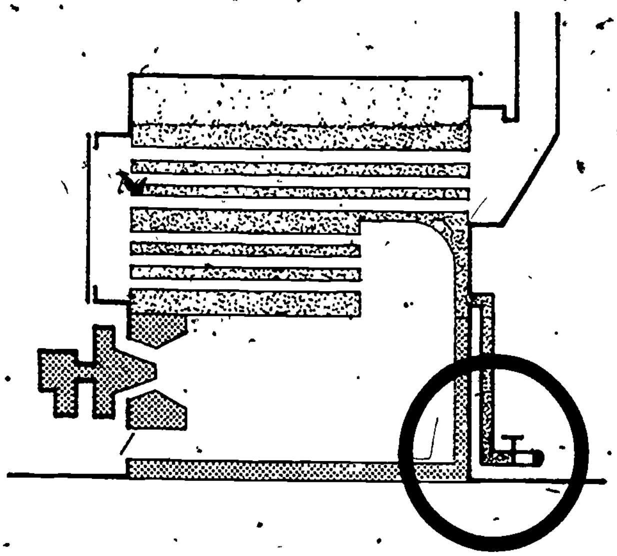
make arrangements to have the oil storage tank cleaned before the problem becomes serious.



Note: Many New York City schools have high and low suction fittings in fuel oil tanks. Use low suction connection for routine operation. This will keep the high suction available for times when sludge or water has collected at the bottom of the tank. High suction should be used only until the tank can be cleaned.



2. BLOW DOWN THE BOILER.



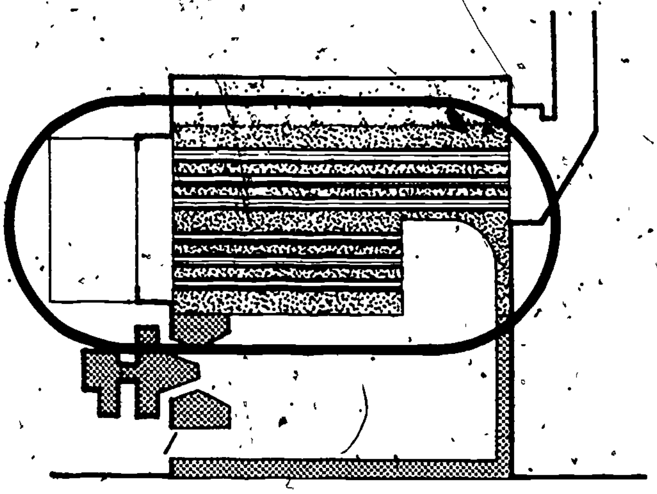
3. TEST pH OF BOILER WATER. Readings should range between 10 and 12 to prevent acid corrosion. If reading is under 10, add soda ash (sodium carbonate Na_2CO_3) to the water. For a description of the test, see the Manual of Procedures.

Note: The procedure outlined is for New York City water which is extremely low in calcium content (soft water). Where there is water with high calcium content (hard water), water must be treated to remove calcium to prevent scale build-up on water side of tubes.

4. CHECK THE OXYGEN DEMAND (OD) of boiler water. This tests for the presence of dissolved oxygen in the water which causes oxygen corrosion (rust). Add sodium sulfite as required to maintain a minimum of 20 parts per million (ppm) of sodium sulfite. For description of the test, see the Manual of Procedures.

AFTER ONE HUNDRED OPERATION HOURS

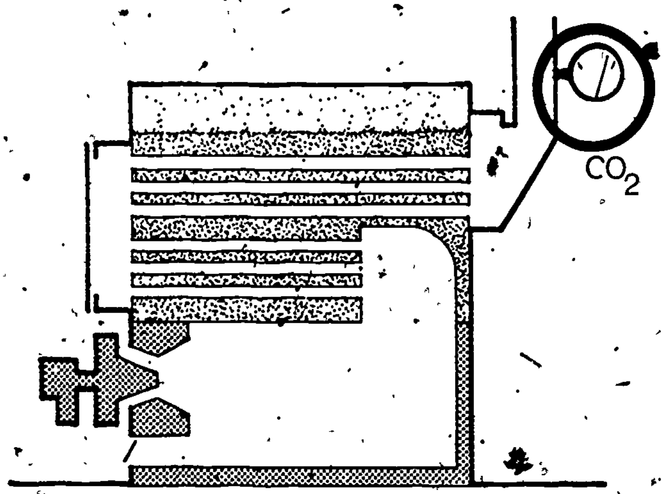
1. VACUUM THE FIRE TUBES.



Note: Close access doors to fire tubes tightly to prevent air leaks. Check the gaskets. Air leaks around doors will reduce effective draft and will draw cold air directly through tubes.

MONTHLY MAINTENANCE

1. TAKE CO_2 READINGS. CO_2 content should be about 12 percent. A significant drop in CO_2 reading indicates



incomplete combustion of fuel caused by an incorrect air-oil mixture because of slipping damper linkage or a problem in oil supply system (strainer, pump, metering device). CO_2 test kits are available at the Borough Supervisor's Office of the Bureau of Plant Operation.

2. CHECK THE OPERATION OF DAMPERS. Verify that dampers can move freely to extreme positions. Remove all dirt and obstructions. Verify that no vanes are bent or distorted. Lubricate axles.

YEARLY MAINTENANCE

1. WASH DOWN WATER SIDE AND VACUUM FIRE SIDE OF BOILER TUBES.

2. VACUUM THE BREACHING.

3. CLEAN ALL FUEL OIL PASSAGES AND CHAMBERS in fuel oil burner with solvent.

4. CHANGE LUBRICATING OIL in burner.

5. CRACKED OR LOOSE BRICKS in combustion chamber should be repaired or replaced.

6. CHECK INSULATION on all hot air ducts and steam supply pipes. Where defective, it should be replaced.

7. CHECK AIR VALVES.

8. CLEAN AND CHECK VACUUM TRAPS AND THERMOSTATICALLY CONTROLLED STEAM VALVES AT RADIATORS.

9. CHECK DAMPER OPERATING CONTROLS. These include chains, motors, gears and linkages. Make sure that damper positions are adjusted correctly by signals given.

10. CHECK BACK DRAFT DAMPERS in exhaust fan ductwork. They should close tightly when fans are not operating.

11. CHECK FAN DRIVE BELTS.

12. CHECK THERMOSTATS.

13. CLEAN OR REPLACE ALL FILTERS.

14. CLEAN GRILLES AND REGISTERS AND LOUVERS. Do not change settings after they have been adjusted.

BUILDING MAINTENANCE

In order to keep heat in the building, watch for possible sources of air leaks. Check all seals (at doors and windows) frequently. Include the following operations in the maintenance routines.

> Note: Although care of refrigerator and freezer gaskets is not technically part of building maintenance, your attention is called to them because defective gaskets can greatly increase the use of electric energy. Check them periodically and repla[illegible] when required.

EXTERIOR DOORS

1. CHECK OPERATION PERIODICALLY (both sets where there are vestibules). They should not remain open and cause unnecessary heat loss during heating season.

2. CHECK GASKETS AND WEATHERSTRIPPING once a year and replace as needed.

3. SET DOOR CLOSERS (checks) so that they close as rapidly as possible without creating a safety problem.

WINDOWS

1. CHECK SASH for proper closing once a year.

2. CHECK GASKETS AND WEATHERSTRIPPING once a year and replace as needed.

3. REPLACE BROKEN GLASS IMMEDIATELY.

CAULKING

1. CHECK FOR DRIED OR MISSING CAULKING once a year and replace as required.

standards

Until recently, as long as energy was cheap and plentiful, ventilation and lighting systems were designed to produce levels to satisfy the worst condition and most demanding requirements at all times.

Quantities of air in ventilation systems are based on requirements for cooling during the spring, summer and fall, rather than on the amount of air necessary for body metabolism. This results in the introduction of excess air during the heating season, which must be heated to room temperature. This excess heating load requires the burning of large quantities of oil and coal.

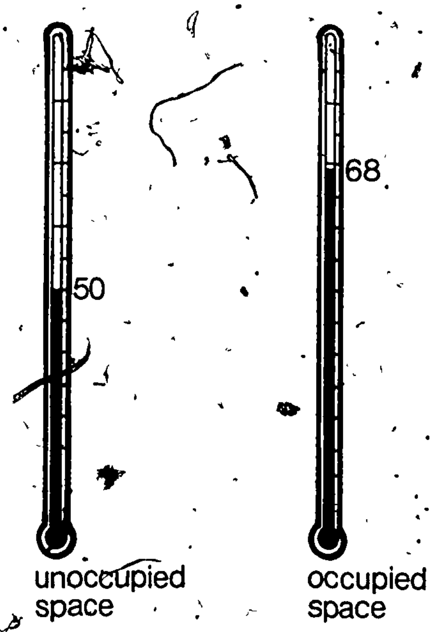
Lighting systems in classrooms are designed to accommodate at all times the most demanding visual tasks such as sewing or fine drafting even though the activities which normally occur in these classrooms - lectures, discussions, reading, and writing - require less than half that quantity of light.

The rapidly increasing price, and decreasing availability of energy has made it necessary to review the basic standards for services provided by energy consuming systems. This section describes and discusses a revised set of standards, based on extensive research carried out by the American Society of Heating, Refrigerating and Air-Conditioning Engineers, the National Bureau of Standards, the John B. Pierce Foundation, the University of Minnesota, and independent research groups. The section also includes some discussion of methods of determining existing conditions and of modifying them to conform to the standards.

Since these modifications are generally outside the scope of a custodian's responsibility, their discussion here has been kept to a minimum. For complete instructions on these procedures, see the Appendix.

HEATING

The standard for heating levels to be used for all occupied spaces is 68° F. Unoccupied spaces may be kept at 50° F. Since the level of heat is maintained by thermostatic control, it is important to keep thermostats set at the standard temperatures and to make certain that they are operating properly.

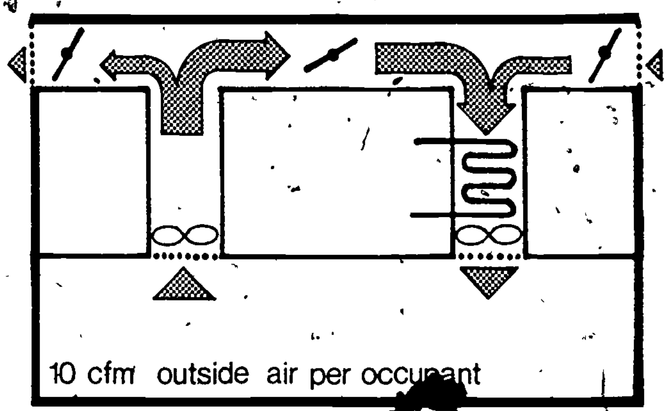


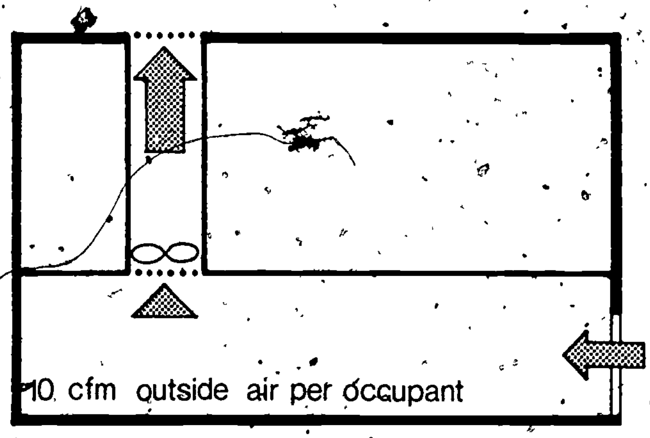
VENTILATION

STANDARDS

Ventilation systems in recently built school buildings are designed to provide a minimum of 15 cubic feet per minute (CFM) for each classroom occupant and up to 50 CFM for each occupant in special areas such as gymnasiums, auditoriums and cafeterias. When operated according to these design criteria, ventilation accounts for two-thirds the heating load of a building.

Note: In winter, all incoming outside air must be heated and an equal amount of inside air, which has already been heated, must be exhausted (with its embodied heat) to make room for the new outside air. Where only mechanical exhaust is provided (the typical setup in most school classrooms which have window supply and mechanical exhaust) the amount of outside air entering the building through openings or infiltration is the same as that being exhausted even though there is no mechanical supply.

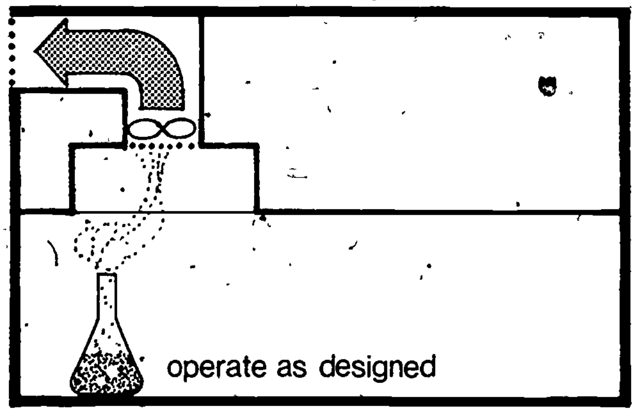




In order to minimize the heating load and increase energy efficiency, the amount of outside air taken in and the corresponding amount of heated air exhausted should be decreased to be no more than that which is required for health and comfort. This amount, according to the research cited in the introduction to this section, is 10 CFM per occupant and shall be considered the standard for ventilation of all areas except where there is intense physical activity, heavy smoking, the production of noxious fumes, or where the system is being used for cooling. The exceptions and their applicable standards are the following:

1. Gymnasiums. The ventilation should provide 15 CFM per occupant actually involved in sports or other strenuous activities. In cases where there are spectators in the gymnasium, the 15 CFM applies only to the actual participants while the spectators shall each be provided with 10 CFM of outside air.

2. Shops where noxious fumes are produced. Operate the ventilation systems as originally designed.



3. Science classrooms with fume hoods. The exhaust system shall be operated at the original design rate when required. It should be stressed, however, that fume hood systems exhaust very large quantities of air and should not be run except when actually in use.

4. Kitchen hoods. These should be run at the rate designed. However, these, too, should be run only when actually required. (Note: Filters in hoods should be cleaned regularly to minimize energy used in operation of fans.)

5. Toilet rooms. The exhaust systems should be run as designed.

Operation of ventilation systems should be modified to provide no more than these standards (under the direction of Engineering); supply and exhaust fans should be run only when required to meet the standards (by the custodian).

DETERMINATION AND EVALUATION OF EXISTING VENTILATION RATES

Before considering modifications, it is necessary to find the actual amount of outside air which is introduced into each space under existing conditions and then to compare these amounts with the standards listed above. Instructions to do this can be found in the Appendix on p. a/st-45.

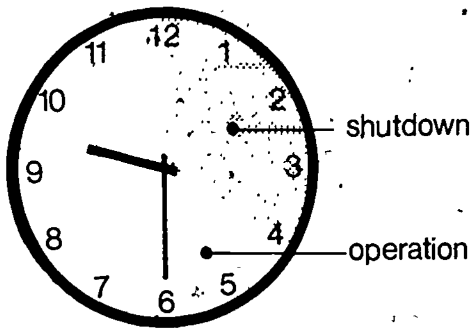
MODIFICATIONS

Modification of ventilation systems is generally not part of a custodian's responsibility. It is important, however, for energy conservation, to be aware of the methods which can be used to reduce existing ventilation rates. They are as follows:

1. Increasing the amount of air recirculated. This is possible in systems in which heated air is supplied mechanically and exhaust air is returned mechanically. In

most of such systems a portion of the return (exhaust) air is mixed with outside air and recirculated, and only the remainder of return air is exhausted from the building. In schools this type of system is generally used only in gymnasiums, auditoriums, and cafeterias.

2. Staggering the use of the fans. This can be done in systems in which air is supplied non-mechanically (through windows and by infiltration), and the exhaust air is returned mechanically (through a duct system). The exhaust rate can be reduced by running the fans for only part of the time a space is occupied. For example, if, instead of



ventilation sequencing

letting the exhaust run for 60 minutes, it is run for 40 minutes and shut off for 20 minutes. The amount of air exhausted is thereby reduced by one-third, and correspondingly, the amount taken in is also reduced by one-third. This staggering can be done manually, which has the disadvantage of requiring continuous attention (for which manpower may not be available), or electrically by an automatic timer which can be installed in the system.

B. Changing the drive ratio, that is, the ratio of the motor pulley to the fan pulley. This method is also applicable in systems where there is window supply and mechanical exhaust.

Further discussion of these methods and their implementation is included in the Appendix.

LIGHTING

STANDARDS

Of the standards relating to environmental conditions, those pertaining to lighting are the least exact and the most subjective. Outdoors the eye must frequently switch from objects which are illuminated to several thousand footcandles in direct sunlight to those at several hundred footcandles in the shade of a tree or a wall. Inside a room with a north-facing window (no direct sunlight) light levels frequently range from three or four hundred footcandles to less than five footcandles. Until recently, it was assumed that the ideal working environment was one of uniform illumination. Recent research, however, has indicated that the eye, like every other part of the body, requires a certain amount of exercise for comfort and well being.

Two important facts must be remembered in considering revised standards for lighting in the school classrooms. The first is that the proposed levels will have absolutely no negative impact on ocular health (see Appendix p. a/st-51.)

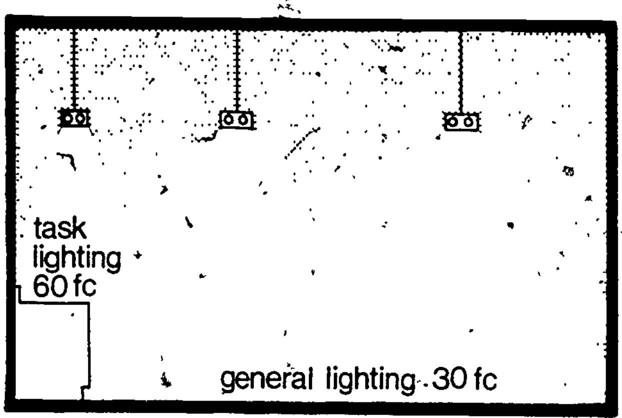
The second is that the lower light levels proposed will have no significant negative impact on the ability to carry out any visual task associated with normal classroom use. (See Appendix p. a/st - 53.)

It is important to remember that the standards, and modifications to achieve those standards, outlined in this section do not suggest anything which will in any way interfere with the health, safety, or educational performance of those in the school system. Implementing them provides the means to reduce the amount of scarce educational dollars which goes to the utility companies and oil producers instead of education.

In classroom areas, a light level of 30 footcandles is adequate for almost all activities which take place there and satisfies all New York City agency requirements. Light supplied at higher levels in these areas represents an unnecessary use of electricity.

In service areas such as corridors, toilet rooms, utility rooms, etc., the lowest possible light levels consistent with use and safety requirements should be used. Current standards for Federal office buildings call for an average light level of 10 footcandles for corridors. This may be used as the standard for those areas in which no demanding visual tasks are performed.

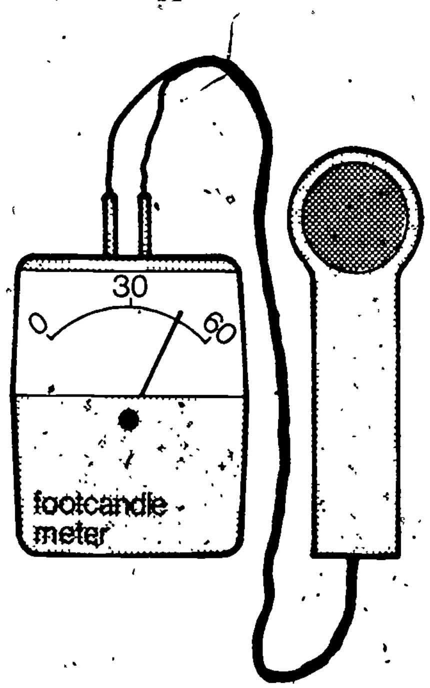
There are, however, certain tasks which require light levels higher than 30 footcandles. In New York City schools, these are primarily the tasks performed in shops, sewing rooms, drafting rooms, and some art rooms. Even in those areas, the lighting requirements may vary within a space. It is often possible to reduce the overall lighting to 30 footcandles and maintain the light level at specific work stations by using existing overhead sources, or by supplementary sources which are already



mounted above work counters, or by work lights mounted directly on pieces of equipment such as drill presses, sewing machines, drafting tables, etc. Rooms which require a uniformly high level of light should be lighted to a level of 60 to 70 footcandles. Any major program of changing existing light levels should be carried out under the direction of the Bureau of Plant Operations.

DETERMINATION OF EXISTING LIGHT LEVELS

The first step in determining whether energy-saving lighting reductions can be made is to find the existing light levels in every space and record them on a set of lighting plans. This can be done either by taking actual readings using a footcandle meter or by calculations. For instructions, see Appendix.



EVALUATION AND MODIFICATION OF EXISTING LIGHT LEVELS

The second step is to compare the existing light levels with the standards recommended above in order to determine whether or not modifications are indicated. Light levels which exceed the standards can be reduced by the methods listed below. Descriptions of these methods and instructions for their application are included in the Appendix.

Note: Except for the substitution of lamps of lower wattage than those existing, these operations are generally not within the scope of the custodian's responsibilities and can be implemented through the Bureau of Plant Operations.

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incandescent

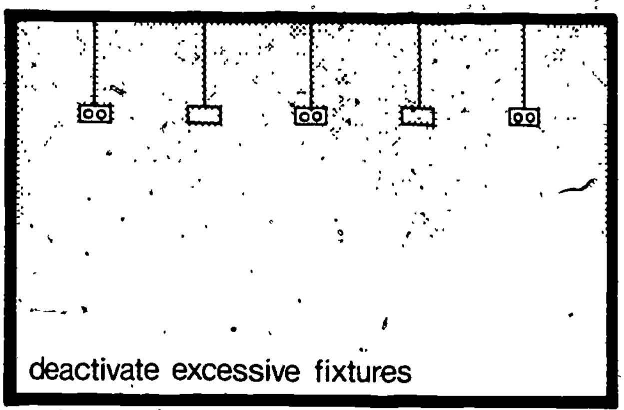
Light levels from incandescent fixtures can be reduced either by replacing existing lamps with lower wattage lamps or by reducing the number of fixtures or lamps in operation by the removal of lamps.

fluorescent

Reduction of light intensity where fluorescent fixtures are used can be accomplished by using lower wattage lamps, deactivating some of the fixtures, or reducing the number of lamps per fixture.

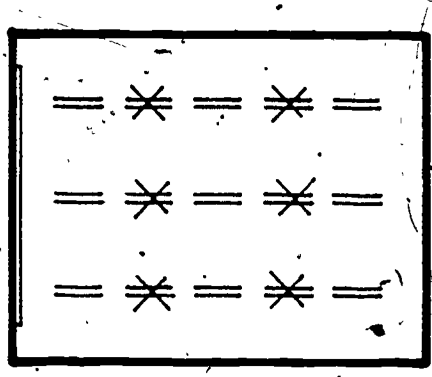
> Note: In delamping, whenever one lamp served by a ballast is removed, all lamps served by that ballast must be removed in order to prevent the ballast from burning out.

The diagrams on page st-28 illustrates typical lighting patterns and how they can be modified to result in lower light output.

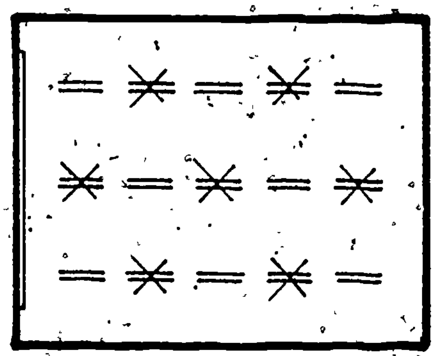


TYPICAL DELAMPING PATTERNS TO ACHIEVE 30 FOOTCANDLES

rooms with 30 four-foot tubes

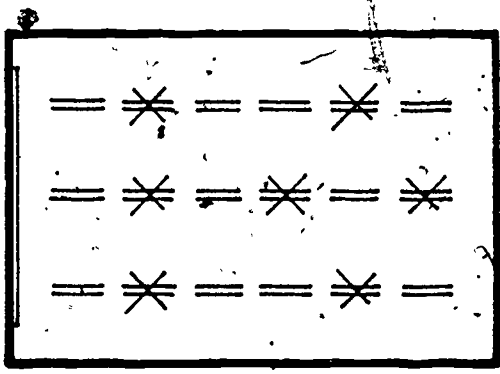


existing: 50 footcandles
delamp: 12 tubes

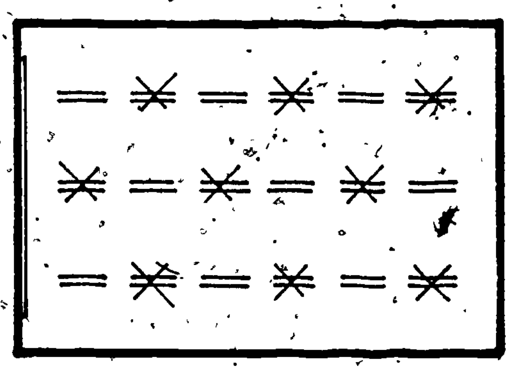


existing: 60 footcandles
delamp: 14 tubes

rooms with 36 four-foot tubes

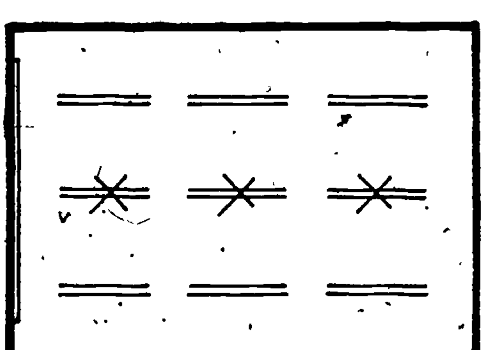


existing: 50 footcandles
delamp: 14 tubes



existing: 60 footcandles
delamp: 18 tubes

rooms with 18 eight-foot tubes



existing: 50 footcandles
delamp: 6 tubes

Note: These diagrams indicate an approach to, and possible patterns for, delamping.

SUMMARY

A program of energy conservation related to lighting can be summarized as follows:

1. Determine whether existing light levels are too high.

2. In incandescent installations, reduce excessively high light levels by reducing the wattage of lamps installed.

3. In fluorescent installations, reduce excessively high light levels either by using 35-watt lamps in place of 40-watt lamps where available and applicable, or by one of the delamping methods.

4. Where the requirements for light within a space vary due to fixed equipment, utilize a delamping program to reduce light levels except in the specific areas which require higher levels.

scheduling

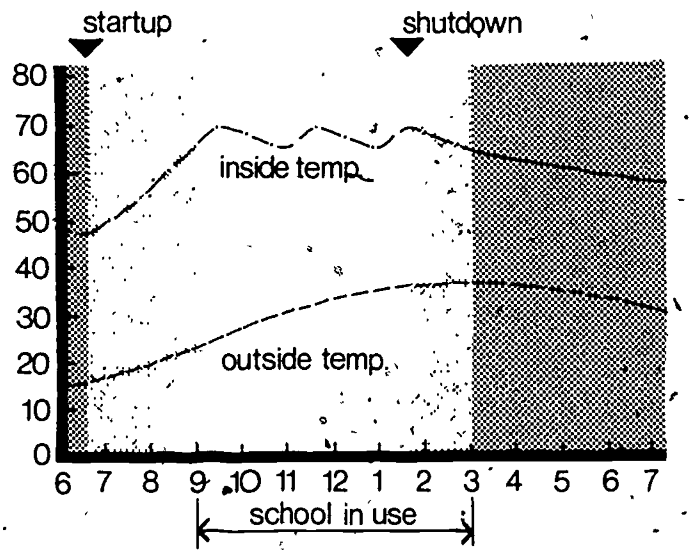
The preceding sections have described plant operating techniques necessary for optimum performance from energy-using equipment, have set minimum standards for equipment output required for the health and comfort of the occupants, and have described methods of modifying the existing equipment so that its output does not exceed these standards. This section deals with methods of scheduling and controlling the use of the equipment to provide services only when the spaces are occupied and only to the extent required by physical conditions and types of activity. The implementation of these methods will further contribute to energy conservation.

HEATING

Scheduling the operation of the heating system for energy efficiency when the building is occupied involves minimizing morning start-up time and taking maximum advantage of afternoon "coasting." This requires timing the firing of the boiler so that the standard operating temperature (68° F.) is reached just at the time that the building is occupied, and the shutting down so that the temperature is maintained only so long as the building is occupied.

> Note: Firing the boiler 20 minutes earlier than necessary in the morning and shutting it down 30 minutes later than necessary in the afternoon results in a 10 percent increase in the basic 8-hour heating day.

Scheduling also involves minimizing the number of heating zones occupied and heated in schools where the heat distribution systems are laid out according to heating zones. In those systems, the supply of heat to each zone is governed by a centrally located steam main valve which can be turned off when that zone is not occupied. For times when the building is partially occupied (after school hours), a program should be developed which concentrates activities according to heating zones and limits occupancy to as few zones as possible.



At times when the building is not occupied, standard procedure in New York City schools is to shut down the heating plant. It may be necessary, however, to provide short intervals of heating to prevent freezing of pipes during extended shut-downs in cold weather.

DETERMINE START-UP TIME

The optimum start-up time is dependent on the outside temperature and the inside temperature before the heat is turned on.

> Note: If the building has become colder than usual because of particularly low nighttime temperatures, it will take longer to heat than it would under normal conditions for the same outside morning temperature. See the Appendix for instructions to determine these times.

DETERMINE SHUT-DOWN TIME

The optimum shut-down temperature is dependent on the outside temperature. The amount of coasting time possible decreases as the outside temperature decreases. See instructions in the Appendix for procedures to determine the best shut-down times for varying temperatures.

> Note: It is important to determine shut-down times based on occupied spaces in an occupied building. (As mentioned in the section on Plant Operation, occupants and lights make a sizeable contribution to the heat in a room, and an empty room cools down faster than one which is occupied.)

VENTILATION

Scheduling with regard to ventilation systems means considering outside temperature and the use and non-use of spaces in the determination of periods of operation of the systems.

EXHAUST SYSTEMS

In those areas where air is supplied by infiltration and is exhausted mechanically (exhaust systems) the use of exhaust fans should be limited to times when the building is occupied, times when the spaces served are occupied, and when the required heat levels have been reached.

To do this, first identify the spaces served by each exhaust fan (exhaust zones) and then develop a program for the use of the fans according to the use of the spaces. With the cooperation of the administration, a program can then be developed for times when the building is only partially in use, which will concentrate activities in a single exhaust zone whenever possible and otherwise in as few zones as possible. In this way the number of fans in use, and consequently the amount of energy spent, can be reduced.

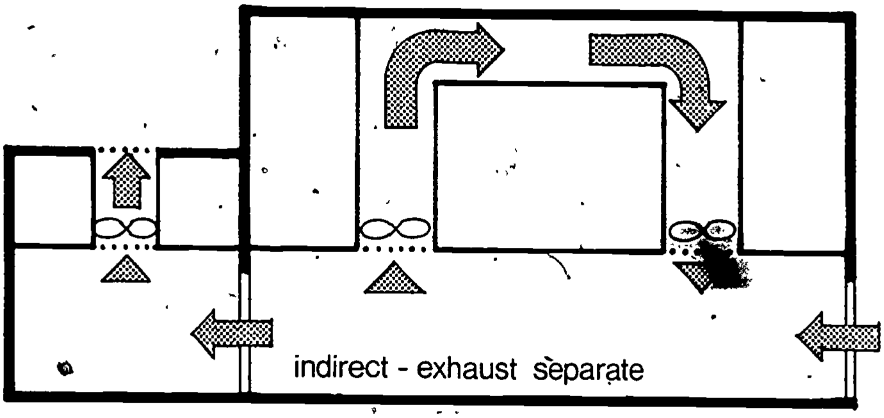
See the Appendix for discussion of procedures necessary to develop these programs.

INDIRECT AIR HEATING SYSTEMS

Two types of systems in which air is heated, supplied, and returned mechanically (indirect air heating systems) are used in New York City schools. One uses a separate system for exhausting air, and the other incorporates supply, return, and exhaust in one system. Applicable methods of scheduling for efficient energy use differ according to the system; however, the matching of fans and spaces served is necessary to develop a program for the use of both systems. The procedures are similar to those discussed under exhaust systems and are described in the Appendix.

indirect with separate exhaust

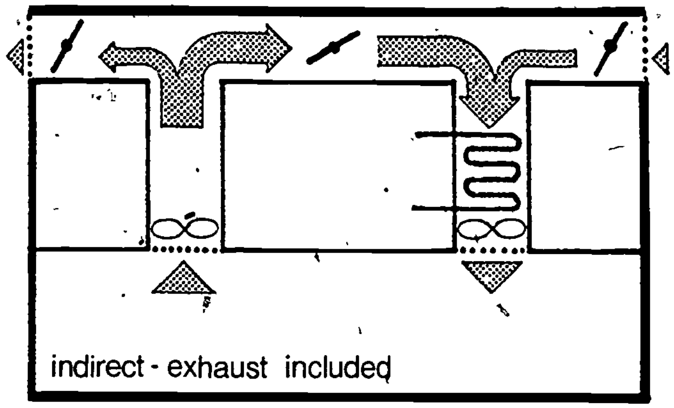
In areas which are served by an indirect air heating system and separate exhaust system, set the heating system at 100 percent recirulation and use the exhaust only as described above under EXHAUST SYSTEMS.



For example, a gymnasium is connected to locker rooms with their own exhaust fans which draw air from the gymnasium. If the gymnasium air system is set at 100 percent recirculation, the air drawn from the gym by the locker room exhaust will be made up of outside air provided by infiltration, either from leakages at the gym windows or from other parts of the school. In such a situation, the scheduling of the gymnasium indirect system is not crucial since it will not result in the unnecessary discharge of heated air to the outdoors. The locker exhaust, however, must be controlled to run only when the spaces are occupied.

combined system supply, return, and exhaust

In areas where one system supplies outside and heated air, returns air for recirculation, and exhausts air, the operation of the system must be carefully controlled to avoid unnecessary dumping of heated air. To do



this and thereby operate most efficiently, follow these guidelines:

1. Adjust the fresh air dampers to permit a maximum outside air intake of 10 CFM per occupant.

2. Turn the system off when the space is not occupied. This will stop the dumping of heated exhaust air as well as curtailing the supply of heat to the room.

3. If possible, set the system for 100 percent recirculation when the space is not occupied and set it for an outside air intake of 10 CFM per occupant when the space is occupied.

4. When heat is required for an unoccupied space, use the system set at 100 percent recirculation wherever possible. Where the system does not permit this, turn it on only until the acceptable temperature is reached.

5. At the times when the boiler is shut down for coasting (such as afternoons), do not run the system unless it can be set for 100 percent recirculation.

LIGHTING

Operation of lighting in most areas in schools is not controlled by the custodian. Lighting in the following areas, however, is in his control, and using the methods outlined, he can limit the use of electricity in those areas.

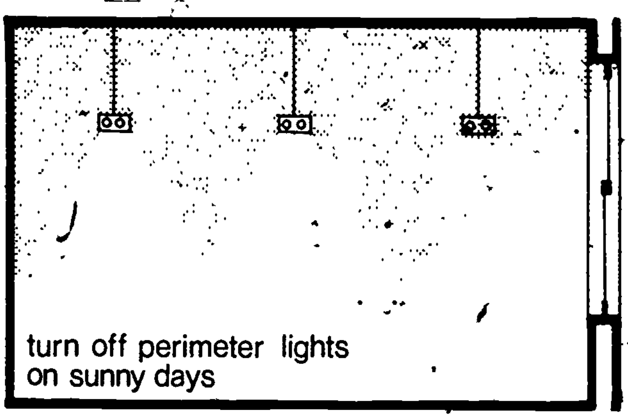
CORRIDOR LIGHTING

In schools where one circuit per floor controls the lights in the corridor, switch off these lights when the floor is unoccupied. Where there are two circuits on a floor which control the corridor lights in a staggered pattern, use one circuit (approximately half the lighting fixtures) for normal corridor illumination. On the other circuit, delamp all except one or two fixtures in each stretch of corridor, and use that circuit at those times when the building is not occupied by students. In this way you will provide sufficient light for safety and security without providing the same amount of light that would be required when the building is fully occupied.

Note: This practice is in keeping with general procedures in effect since the 1973 energy crisis.

PERIMETER LIGHTING

In schools where the rows of light fixtures closest to the windows are on circuits separate from those which control the other fixtures in the rooms, these perimeter fixtures can be deactivated at the circuit breaker. When this has been done, it is impossible to operate those lights from the room switches. Deactivate these circuit breakers whenever outside conditions permit (daylight ranging from partially overcast to full sun), and prevent the unnecessary use of the perimeter lights. To facilitate the operation, make sure that the switches in each panel box which control the perimeter lights are clearly identified.



appendix

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Note: Do not remove TABLES from the book. Additional copies may be requested from the Bureau of Plant Operation.

appendix
plant operation

HEATING

TROUBLESHOOTING

Using TABLE 1 — TROUBLESHOOTING CHART, find the applicable symptom in the column at the left, and, reading horizontally to the right, at each point where a box has been placed, read vertically up to find each of the problems which could be the cause of the symptom. Where more than one problem applies to a symptom, investigate for the presence of each until you have determined the cause of the symptom. The numbers in the boxes correspond to the list of remedies to the right of the chart.

TABLE 1
TROUBLESHOOTING
CHART WITH REMEDIES

SYMPTOMS / PROBLEMS	1 sludge in fuel oil tank	2 cold fuel oil tank	3 water in fuel oil	4 fuel oil suction system: air leaks	5 oil too cold at burner	6 oil too hot at burner	7 low pressure in oil supply pump	8 metering valve: oversupply of oil	9 metering valve: low supply of oil	10 clogged fuel oil strainers	11 burner receiving too little oil	12 loose belts: fuel [illegible]
1 noisy oil pump: thumping sound		3		11								
2 dirty fuel oil strainers	1											
3 low pressure fuel oil discharge	1			11						12	6	[illegible]
4 carbon in atomizer cup					4							
5 whistle at burner start					4							
6 squealing belts												
7 vibration at burner												
8 unsteady flame		3			4		11		5	12		
9 pulsating flame			2		4							[illegible]
10 bright yellow flame									5	12		
11 dark flame					4			5				
12 smokey fire					4			5				
13 sparks in flame			1		4	4			5			[illegible]
14 hissing or frying noise			1									
15 impingement on side walls												
16 impingement on rear wall								5				
17 carbon in combustion chamber					4							
18 draft pressure too high												
19 draft pressure too low												
20 stack temperature too high									5			
21 condensate return temperature rise												

7 low pressure in oil supply pump	8 metering valve: oversupply of oil	9 metering valve: low supply of oil	10 clogged fuel oil strainers	11 burner receiving too little oil	12 loose belts: fuel oil service pump	13 atomizer cup: dirty	14 atomizer cup: damaged	15 atomizer cup: in wrong position	16 burner drive belt: loose or broken	17 burner: shaft bearings worn	18 burner: drive shaft bent	19 position of adjustable air nozzle	20 adjustable relief valve problem	21 primary air supply: too high	22 primary air supply: too low	23 secondary air supply: too high	24 secondary air supply: too low	25 over-fire damper: open too much	26 over-fire damper: closed too much	27 air leaks at boiler doors	28 fire tubes need cleaning	29 leaking steam traps
			12	6	10								7									
							15	16			8											
									13													
							15			9	8											
11		5	12											18								
					11									18		18				19	20	
		5	12											18		18		18				
	5					14									18		18		18	19	20	
	5					14									18		18		18	19	20	
		5			11	14	15							18								
							15					17			18							
	5											17		18								
						14	15	16			8	17			18		18		18			
																18		18				
																	18		18			
		5														18		18			20	
																						21

22 primary air supply: too low	23 secondary air supply: too high	24 secondary air supply: too low	25 over-fire damper: open too much	26 over-fire damper: closed too much	27 air leaks at boiler doors	28 fire tubes need cleaning	29 leaking steam traps
	18				19	20	
	18		18				
18		18		18	19	20	
18		18		18	19	20	
18							
18		18		18			
	18		18				
		18		18			
	18		18			20	
							21

REMEDIES

1 Arrange for oil tank cleaning.

2 Arrange to have water pumped from oil tank.

3 Heat fuel oil to temperature not to exceed flash point.

4 Adjust fuel oil heater at burner.

5 Adjust metering device.

6 Adjust pump pressure.

7 Adjust or repair relief valve

8 Repair burner drive shaft.

9 Replace defective drive shaft bearings.

10 Adjust or replace fuel pump belts.

11 Find source and stop air leakage into suction lines.

12 Clean strainers.

13 Replace all belts.

14 Clean atomizer cup.

15 Replace defective atomizer cup.

16 Adjust atomizer cup.

17 Ajust nozzle for properly shaped fire.

18 Adjust air damper.

19 Make sure doors are tightly closed; check gaskets and arrange to have them replaced if required.

20 Clean boiler tubes.

21 Isolate trap and make repairs.

VENTILATION

MODIFICATIONS

Before making modifications, find the actual amount of outside air under existing conditions which is introduced into each space in cubic feet per minute per occupant and record the amounts on a set of ventilation plans. Instructions to do this follow.

find existing ventilation rates

1. Determine the number of occupants. Find the area of the room. For classrooms divide the area by 20 SF per occupant to find the number of occupants according to the New York City Code. For square foot allowances for other occupancies, see Table 2.

2. Determine the total amount of air (in cfm) being supplied and exhausted from the space. Using the original heating and ventilating drawings, total the small numbers near the arrows at the supply grilles and separately those at the return grilles. These numbers indicate the cfm of air being supplied and exhausted through those grilles. See the plan on page a/st - 47.

Note: Where a room is provided with both mechanical supply and exhaust, total amounts supplied and exhausted separately and use only the larger of the two amounts for the calculations.

3. Divide the amount of air supplied or exhausted determined in Step 2 by the total number of occupants to find the cubic feet per minute of outside air per minute of outside air per occupant.

4. Example - using Classroom 325 on page a/st - 47.

- The plan indicates the space has 37 occupants.

- Using the numbers at the arrows pointing into the grilles (140, 140), and 280), a total of 560 cfm is being exhausted from the room.

- 560 cfm divided by 37 occupants means that the existing ventilation rate is 15 cfm per occupant.

- Evaluation: The revised standard was set at 10 cfm per occupant. The existing rate is therefore higher than required and should be modified.

methods of modification

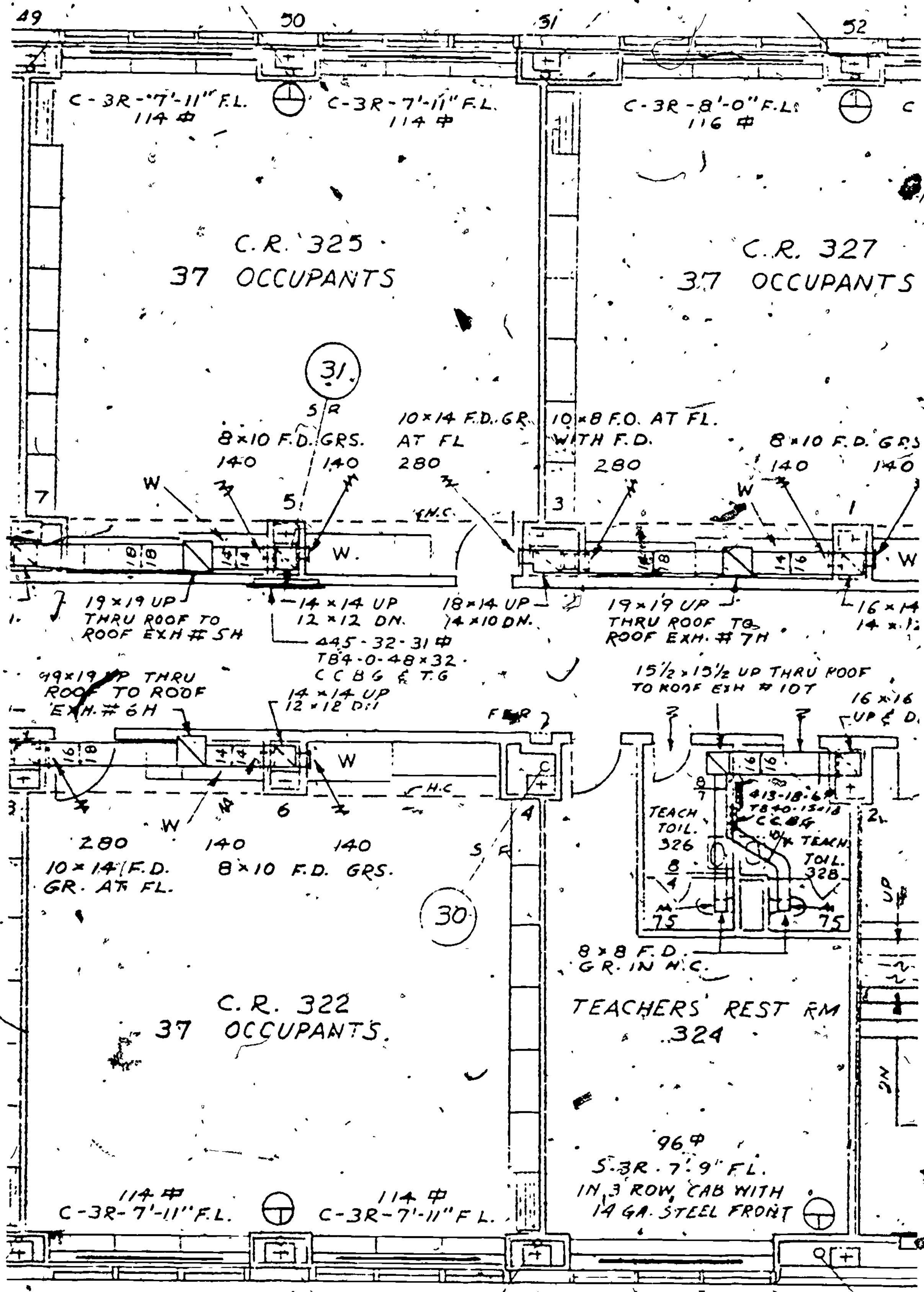
1. Increasing the amount of air recirculated.

- Where provided, set dampers for the lowest possible air intake.

- If there is a recirculation crossover and no dampers have been provided, install a baffle at the fresh air intake to reduce the amount of incoming air. Make up the baffle out of fireproof sheet material such as light guage steel.

2. Automatic staggering of fans. Installation of automatic timers to carry out the sequencing of the operation of fans as described on page st - 22 may be feasible in schools which have very large exhaust fans or numerous small fans controlled from a single electric panel box. An analysis of the system should be made through the Bureau of Plant Operations to determine whether the

CLASSROOMS: HEATING AND VENTILATION PART PLAN

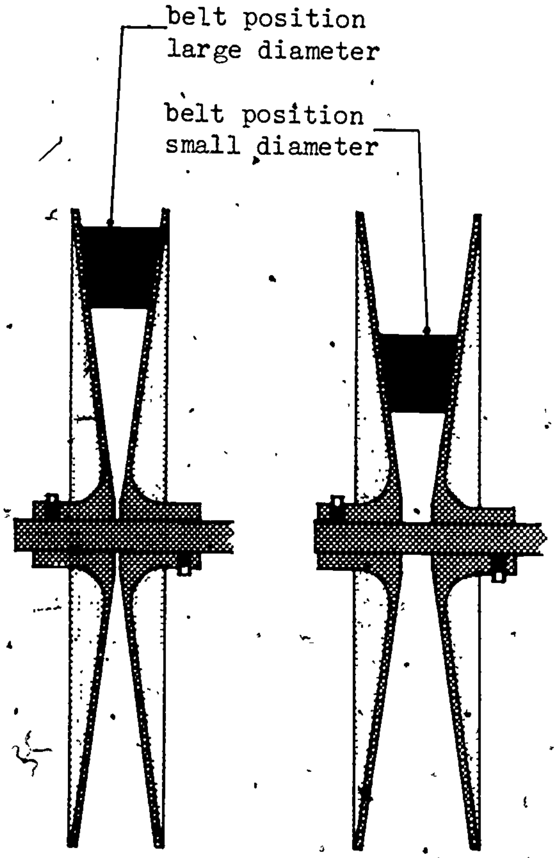


potential savings from the installation of such a system are sufficiently large to warrant the cost.

3. Modifying the drive ratio by changing pulley sizes.

- For non-adjustable pulleys, replace an existing motor pulley with a smaller one, and an existing fan pulley with a larger one to reduce the fan speed.

- For adjustable pulleys located on the motor side, decrease the effective size of the pulley to reduce the fan speed.



adjustable pulley

- For adjustable pulleys located on the fan side, increase the effective size of the pulley to reduce the fan speed.

procedure to determine modifications

1. <u>Find the required reduced air quantity factor</u> by dividing the desired ventilation rate (10 cfm per occupant) by the existing ventilation rate (15 cfm per occupant). For the example above, this is 0.67.

   <u>Note</u>: When fans are operated at less than 0.40 of their design speeds, their performance becomes erratic. Therefore, the smallest reduced air quantity factor should be 0.40.

2. <u>Determine existing motor pulley to fan pulley ratio</u> (drive ratio) by dividing the motor pulley diameter by the fan pulley diameter. If the motor pulley has a 4-inch diameter and the fan pulley has an 8-inch diameter, the drive ratio is 4 inches divided by 8 inches or 0.5.

Another way of determining the pulley ratio is to make marks on the outer edges to the motor and fan pulleys. Move the belt by hand and count the number of revolutions made by the motor pulley for each complete revolution of the fan pulley. The pulley ratio will be one (fan pulley revolution) divided by the number of motor pulley revolutions.

For the example in Step 2, it will be found that the motor pulley makes two revolutions for one revolution of the fan pulley, and therefore the pulley ratio is 1 divided by 2 or 0.5.

3. Determine the desired pulley ratio using the following formula:

present pulley ratio x air flow reduction = revised pulley ratio

In the example above, since the existing pulley ratio is 0.5 and the reduced air quantity factor is 0.67, the formula is:

0.5 x 0.67 = revised pulley ratio = 0.335.

4. Determine the changes to be made by one of the following methods:

- To modify the motor pulley, find the required diameter by multiplying the fan pulley diameter by the revised pulley ratio.

In the example above, since the existing fan pulley diameter is 8 inches and the revised pulley ratio is 0.335, the formula is:

8" x 0.335 = revised motor pulley diameter = 2.68" say 2 5/8"

- To modify the fan pulley, find the required diameter by dividing the existing motor pulley diameter by the revised pulley ratio.

In the example above, since the existing motor pulley diameter is 4 inches and the revised pulley ratio is

a/st - 50

0.335, the formula is:

$$4'' \div 0.335 = \text{revised fan pulley diameter} = 10.9''$$

- To modify adjustable pulleys, either reduce the size of the motor pulley or increase the size of the fan pulley. Then make marks on the outer edges of the motor and fan pulleys. Move the belt by hand and count the number of revolutions made by the motor pulley for each complete revolution of the fan pulley.

Compare the actual new pulley ratio to desired pulley ratio using the formula:

$$1 \div \text{number of motor pulley revolutions} = \text{new actual pulley ratio}$$

If the new actual pulley ratio is greater than the desired new pulley ratio, continue to decrease the size of the motor pulley or increase the size of the fan pulley. If the actual new pulley ratio is less than the desired new pulley ratio, partially increase the size of the motor pulley or decrease the size of the fan pulley. Repeat this process until the desired ratio is achieved or until the maximum limits of adjustment have been reached.

LIGHTING

BACKGROUND INFORMATION

relationship of illumination levels to ocular health

Dr. D. G. Cogan of the National Institute of Health has said the following: "Illuminating engineers have believed the more light, the better...But, more to the point, they have repeatedly implied that low illumination, or what for their purposes is better called 'inadequate lighting,' is harmful to the eyes. Ophthamologists have rarely taken the trouble to express their beliefs in print, but nevertheless, have been privately convinced that the health claims have little foundation. To wit, the diseases supposedly caused by low illumination have not found their way into the ophthamologists' nosology."[1]

In his paper, Extrapolation of Visual Physiology and Pathology Findings to Design of Lighting Systems, Dr. Robert D. Reinecke of the Department of Ophthamology, Albany Medical College, cites only one case in which low light levels are known to create lasting ocular damage. This is the syndrome known as "miner's nystagmus." (Nystagmus is an uncontrollable back-and-forth motion of the eyes.) Prior to the turn of the century, it was found that after about 25 years of working in poorly lit mines, a number of miners developed nystagmus. By raising the average light levels in the mines to one one-hundredth of a footcandle, the problem was eliminated. A light level of 15 footcandles is 1,500 times greater than that required to prevent this one known disease, induced by low light.[2]

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[1] Cogan, D. G. "Lighting & Health Hazards," Arch. Ophthal., Vol 79, January, 1968.

[2] Reinecke, R. P., "Extrapolation of Visual Physiology and Pathology Findings to Design of Lighting Systems," Federal Energy Admin. Symposium, 29-30 October 1975, Washington, DC.

relationship of illumination levels to learning

Over a 32-year period, Professor Miles A. Tinker of the University of Minnesota conducted extensive research on the effects of light levels on reading. His conclusions are found in the book, Bases for Effective Reading. A series of tests were conducted to relate reading speed to light levels of 0.1, 0.7, 3.1, 10.3, 17.4, and 53.3 footcandles. In tests where subjects were given two minutes of adaptation, rates of reading were the same for 10.3, 17.4, and 53.3 footcandles and considerably lower for 3.1, 0.7, and 0.1 footcandles. With 15 minutes of adaptation, only the light levels of 0.1, and 0.7 footcandles produced a significant retardation in speed. For 3.1 footcandles and above, speed and accuracy of reading remained virtually unchanged. Regarding the question of reader preference, Tinker reports the following results of tests on 144 university students. At one lab session, subjects adapted 15 minutes to 8 footcandles, at another to 52 footcandles. When adapted to 8 footcandles, subjects tended to choose 8 footcandles as most comfortable; when adapted to 52 footcandles, they chose 52 footcandles most often. "Apparently, by picking an intensity and adapting the reader to it, one can obtain preference for that intensity...If the investigator is interested in promoting use of lights of high intensity, the method of preferences will support it."[3]

[3]Tinker, M. A., Bases for Effective Reading, University of Minnesota Press, 1965.

savings potential through delamping program

A typical fluorescent lighted classroom contains approximately 1,500 to 1,800 watts for the lighting. If an average of 500 watts per classroom can be eliminated, and if those lights would ordinarily be used for 1,500 hours a year including after school and cleaning activities, savings of 750 kwhrs per year per classroom would be made. There are approximately 30,000 classrooms in the New York City school system. If this average 750 kwh/yr saving were made in each, it would produce overall savings of 22,500,000 kwh/yr, which at the present cost of electricity, would result in a cost saving of over 1.3 million dollars. In other terms, since most electricity delivered to New York results from the burning of oil, this program could save almost 2 million gallons of oil per year at the electrical generators.

DETERMINATION OF LIGHT LEVELS

direct readings

This method is simpler, more reliable, and, therefore, preferable to calculations. Meters may be borrowed from the Borough Supervisor's Office of the Bureau of Plant Operation.

1. Take readings in four locations in each room under the most demanding conditions to be met. If a room is used at night (when there is no contributing daylight), take the readings at night or with "blackout" shades drawn.

   Note: Lower room light levels will seem more acceptable visually at night when there is no contrast with higher light levels outside.

2. <u>Note all readings on the plans.</u>

calculations

If the direct reading method is impractical, find the approximate light levels by calculations based on the size of the room, the number and type of light fixtures, and the room finishes. Find the light level for each room using the instructions which follow and record them on the plans for reference.

1. <u>Find the number of watts per square foot.</u>

- Calculate the area of the room.

- Find the total number of watts.
  a. If all the lamps have the same wattage, multiply the total number of bulbs by the number of watts per bulb.
  b. If the lamps used have different wattages, add the wattage of all the lamps.

- Divide the total number of watts by the area of the room to determine the watts per square foot.

2. <u>Find the light level</u> using TABLE 2 for incandescent and TABLE 3 for fluorescent fixtures.

- Find your figure for watts per square foot.

- Determine whether your room finish is light, medium, or dark.

- Determine what fixture type is used in the room.

- Reading down in the column for the appropriate fixture type and across to the right at the correct watts per square foot for the applicable room finish, find the resultant footcandle level.

3. Example: A classroom 25 feet wide by 30 feet long has light grey painted walls, light grey floor tile, and a white painted ceiling. It has three rows of fluorescent fixtures with prismatic wraparound diffusers, each row having six, two-lamp fixtures, four feet long.

- Find the number of watts per square foot.

  a. The area of the room is 750 square feet (30 x 35).

  b. There are 36 fluorescent lamps at 40 watts each or 1,440 watts total.

  c. The watts per square foot are 1,440 watts divided by 750 square feet or 1.92 watts per square foot.

- Find the light level. From TABLE 5 - FOOT-CANDLE LEVELS: FLUORESCENT FIXTURES, a room with lighting at 2.0 watts per square foot, light finishes, and prismatic wraparound diffusers (Lighting Fixture Type F7 from TABLE 3 - LIGHTING FIXTURE TYPE SCHEDULE) has a light level of 51 footcandles.

- Evaluation: The standard is 30 footcandles for classrooms. The existing light level, as determined above, is higher than the standard and therefore should be modified. From TABLE 6, DELAMPING SCHEDULE FOR FLUORESCENT FIXTURES, it can be seen that deactivation of 14 bulbs will result in a lighting level of 30 footcandles.

METHODS OF MODIFICATION

substitute lower wattage lamps

Light output can be reduced by approximately 20 percent most simply by replacement of the standard four-foot, 40-watt lamps with new 35-watt lamps by GE or 34-watt lamps by Sylvania. These lower wattage lamps are available at present only in the four-foot length.

delamping

A more generally applicable method of reducing overall light levels is the complete deactivation of some portion of the lamps in the space. Any one or more of the methods which follow may be used for delamping. See TABLE 6, DELAMPING SCHEDULE FOR FLUORESCENT FIXTURES (based on existing light levels in footcandles) to determine the number of lamps required for an overall light level of 30 footcandles and consequently, the number of lamps to be deactivated.

Note: One ballast generally serves two lamps which makes it necessary to remove lamps in pairs in order to maintain operation of the fixture. When fixtures are partially or wholly delamped, unneeded ballasts should also be disconnected to maximize energy savings. The ballast uses approximately 10 percent of the electric current consumed.

by a fluorescent fixture. Unless disconnected, the ballast will continue to use the same amount of current when lights are switched on even if the fixture has been delamped.

1. Removal of pairs of lamps in a checkerboard or staggered pattern. This will lower the average light level without creating unacceptable variations in the delivered light level in rooms using four-foot fixtures. This method is generally not applicable in areas where eight-foot fixtures are used. In those areas it would result in lighting which is too uneven.

2. Deactivating the center row of fixtures. This may be applicable where the existing lighting consists of three parallel rows of fixtures.

3. Replacement of one lamp in a paired fixture with a "phantom" tube. These are special tubes which draw very little current but provide the necessary load on the ballast to permit the normal lamp in the pair to maintain its operation. Use of this method makes it possible to convert a two-lamp, eight-foot fixture into a single lamp, eight-foot fixture and reduce the energy used by almost half. Thus, the overall light level in a room can be lowered and higher levels can be maintained where required.

Example: In a science classroom with conventional desks and one demonstration table, light levels at the desks can be provided at 30 footcandles with a light level of 60 footcandles provided at the demonstration table by leaving two lamps in the fixture or fixtures located directly above the table.

"Phantom" tubes, however, are still too expensive to make this an economical method of lowering light levels.

4. Rewiring of fixtures so that a two-lamp ballast serves two tubes end-to-end rather than two tubes side-by-side. This technique has the advantage of using each ballast to power two functioning tubes rather than one functioning tube and one "phantom" tube. It also eliminates the need for purchasing special "phantom" tubes. It has the disadvantage of requiring rewiring which must be done by a qualified electrician.

5. Partial delamping of fixtures by removal of one tube from three-tube fixtures or two tubes from four-tube fixtures (and disconnection of the corresponding ballasts) will result in a lower but uniform overall light level.

TABLE 2 - NET FLOOR AREA REQUIREMENTS PER OCCUPANT
(according to the New York City Building Code)

TYPE OF OCCUPANCY	NET FLOOR AREA PER OCCUPANT (SF)
Auditoriums	
fixed seats - total number of seats equals number of occupants	-
moveable seats	10
Classrooms	20
Dining spaces	12
Gymnasiums	[illegible]
Kindergartens	[illegible]
Kitchens	200
Libraries	25
Locker rooms	12

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TABLE 3 - LIGHTING FIXTURE TYPE SCHEDULE

fluorescent fixtures	F1	Metal eggcrate	
	F2	Parabolic metal eggcrate	
	F3	Acrylic prismatic	
	F4	Glass prismatic	
	F5	Plastic eggcrate	
	F6	Aluminum reflector, no diffuser	
	F7	Prismatic wraparound	
	F8	Opal drop dish	
incandescent fixtures	I 1A	Opal glass diffuser	200 watt bulb (PS 30)
	I 1B	Opal glass diffuser	300 watt bulb (PS 25)
	I 1C	Opal glass diffuser	300 watt, extended service bulb (PS 30)
	I 2A	RLM	150 watt bulb (PS 25)
	I 2B	RLM	200 watt bulb (PS 30)
	I 2C	RLM	300 watt bulb (PS 25)
	I 2D	RLM	300 watt, extended service bulb (PS 30)
	I 3A	Multi-ring with silver bowl	300 watt bulb (PS 35)
	I 3B	Multi-ring with silver bowl	500 watt bulb (PS 40)
	I 4A	High bay-white porcelain	250 watt bulb (PS 35)
	I 4B	High bay-white porcelain	500 watt bulb (PS 40)
	I 4C	High bay-white porcelain	1,000 watt bulb (PS 52)
		High bay-aluminum reflector	
	I 5A	Mercury bulb	400 watt bulb (BT 37)
	I 5B	Mercury bulb	700 watt bulb (BT 46)
	I 6	Down light-blackring	150 watt bulb (A23 ES)
	I 7	Down light-metal reflector	150 watt bulb (R 40)

TABLE 4.- FOOTCANDLE LEVELS: INCANDESCENT FIXTURES

FIXTURE	I 1A			I 1B			I 1C			I 2A		
RM FIN (WATTS PER SQUARE FOOT)	LT	MED	DK	LT	MED	DK	LT	MED	DK	LT	MED	DK
0.2	1	1	1	1	1	1	1	1	1	2	1	1
0.4	3	2	2	3	2	2	2	2	2	3	3	3
0.6	4	3	3	4	4	3	4	3	3	5	4	4
0.8	5	4	4	6	5	4	5	4	3	6	6	6
1.0	6	5	5	7	6	5	6	5	4	8	7	7
1.2	8	7	6	9	7	6	7	6	5	9	9	8
1.4	9	8	6	10	9	7	8	7	6	11	10	10
1.6	10	9	7	12	10	8	10	8	7	12	12	11
1.8	12	10	8	13	11	10	11	9	8	14	13	12
2.0	13	11	9	15	12	11	12	10	9	16	15	14
2.2	14	12	10	16	14	12	13	11	9	17	16	15
2.4	15	13	11	18	15	13	14	12	10	19	18	17
2.6	17	14	12	19	16	14	16	13	11	20	19	18
2.8	18	15	13	21	17	15	17	14	12	22	21	19
3.0	19	16	14	22	19	16	18	15	13	23	22	21
3.2	21	17	15	24	20	17	19	16	14	25	23	22
3.4	22	18	16	25	21	18	20	17	15	26	25	23
3.6	23	20	17	26	22	19	22	18	16	28	26	25
3.8	25	21	18	28	24	20	23	19	16	30	28	26
4.0	26	22	19	29	25	21	24	20	17	31	29	28
4.5	30	26	22	35	29	25	28	24	20	37	34	32
5.0	35	29	25	40	33	29	32	27	23	42	40	37
5.5	39	33	28	45	38	32	37	31	26	48	45	42
6.0	44	37	31	50	42	36	41	34	29	53	50	47
6.5	48	41	35	55	46	40	45	38	32	58	55	52
7.0	53	45	38	60	51	43	49	41	35	64	60	56

TABLE 4 - FOOTCANDLE LEVELS: INCANDESCENT FIXTURES (contd.)

FIXTURE	I 2B			I 2C			I 2D			I 3A		
RM FIN	LT	MED	DK	LT	MED	DK	LT	MED	DK	LT	MED	DK
0.2	2	2	2	2	2	2	2	2	2	2	2	1
0.4	4	4	3	4	4	4	4	3	3	4	3	2
0.6	6	5	5	6	6	6	5	5	5	6	5	3
0.8	8	7	7	9	8	8	7	7	6	7	6	4
1.0	9	9	8	11	10	10	9	8	8	9	8	5
1.2	11	11	10	13	12	11	11	10	9	11	10	6
1.4	13	12	12	15	14	13	12	12	11	13	11	7
1.6	15	14	13	17	16	15	14	13	12	15	13	8
1.8	17	16	15	19	18	17	16	15	14	17	15	10
2.0	19	18	17	22	20	19	18	17	16	19	16	11
2.2	21	20	18	24	22	21	19	18	17	20	18	12
2.4	23	21	20	26	24	23	21	20	19	22	19	13
2.6	25	23	22	28	26	25	23	22	20	24	21	14
2.8	27	25	23	30	28	27	25	23	22	26	23	15
3.0	28	27	25	32	30	29	26	25	23	28	24	16
3.2	30	29	27	35	32	31	28	27	25	30	26	17
3.4	32	30	28	37	35	32	20	28	26	32	27	18
3.6	34	32	30	39	37	34	32	30	28	33	29	19
3.8	36	34	32	41	39	36	33	31	30	35	31	20
4.0	38	36	33	43	41	38	35	33	31	37	32	21
4.5	44	42	39	51	48	45	41	39	37	44	38	25
5.0	51	48	45	58	55	52	48	45	42	50	44	29
5.5	58	54	51	66	62	58	54	51	47	57	49	32
6.0	64	61	57	73	69	65	60	56	53	63	55	36
6.5	71	67	63	81	76	72	66	62	58	70	61	40
7.0	78	73	69	88	83	78	72	68	64	76	66	43

WATTS PER SQUARE FOOT

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TABLE 4 - FOOTCANDLE LEVELS: INCANDESCENT FIXTURES (contd.)

FIXTURE	I 3B			I 4A	I 4B	I 4C	I 5A	I 5B	I 6			I 7		
RM FINISH	LT	MED	DK	ALL	ALL	ALL	ALL	ALL	LT	MED	DK	LT	MED	DK
0.2	2	2	2	2	2	2	4	5	.6	.6	.5	2	1	1
0.4	4	4	3	4	4	5	9	11	1	1	1	3	3	2
0.6	6	5	5	6	5	7	13	16	2	2	2	5	4	4
0.8	8	7	7	8	7	9	17	22	2	2	2	7	6	5
1.0	10	9	8	9	9	12	22	27	3	3	3	9	7	6
1.2	12	11	10	11	11	14	26	33	4	3	3	10	9	7
1.4	13	13	12	13	12	16	30	38	4	4	4	12	10	9
1.6	15	14	13	15	14	18	35	43	5	5	4	14	12	10
1.8	17	16	15	17	16	21	39	49	5	5	5	16	13	11
2.0	19	18	17	19	18	23	43	54	6	6	5	17	15	12
2.2	21	20	19	21	19	25	48	60	7	6	6	19	16	14
2.4	23	21	20	23	21	28	52	65	7	7	7	21	18	15
2.6	25	23	22	25	23	30	56	71	8	7	7	22	19	16
2.8	27	25	24	26	25	32	60	76	8	8	8	24	21	17
3.0	29	27	25	28	26	35	65	81	9	9	8	26	22	19
3.2	31	29	27	30	28	37	69	87	10	9	9	28	24	20
3.4	33	30	24	32	30	39	73	92	10	10	9	29	25	21
3.6	35	32	30	34	32	41	78	98	11	10	10	31	27	22
3.8	37	34	32	36	33	44	82	103	11	11	10	33	28	24
4.0	39	36	34	38	35	46	86	109	12	11	11	34	30	25
4.5	45	42	40	44	41	54	102	128	14	13	13	40	35	29
5.0	52	48	45	51	48	62	117	147	16	15	15	47	40	34
5.5	59	55	51	58	54	70	132	166	18	17	17	53	45	38
6.0	65	61	57	64	60	78	147	185	20	19	19	59	50	42
6.5	72	67	63	71	66	86	162	204	22	21	21	65	56	47
7.0	79	73	67	77	72	94	177	223	24	23	22	71	61	51

WATTS PER SQUARE FOOT

TABLE 5 - FOOTCANDLE LEVELS: FLUORESCENT FIXTURES

FIXTURE	F1			F2			F3			F4		
RM FIN	LT	MED	DK	LT	MED	DK	LT	MED	DK	LT	MED	DK
0.2	2	2	2	3	3	3	4	3	3	4	4	3
0.4	5	4	4	6	6	5	7	7	6	8	7	6
0.6	7	6	5	9	8	8	11	10	9	12	11	10
0.8	9	8	7	13	11	10	15	13	12	16	14	13
1.0	11	10	9	16	14	13	18	17	15	20	18	16
1.2	14	12	11	19	17	15	22	20	18	24	22	19
1.4	16	14	13	22	20	18	26	23	21	27	25	22
1.6	18	16	14	25	22	20	29	27	24	31	29	26
1.8	21	18	16	28	25	23	33	30	27	35	32	29
2.0	23	20	18	32	28	25	37	33	29	39	36	32
2.2	25	22	20	35	31	28	40	37	32	43	39	35
2.4	28	24	21	38	33	31	44	40	35	47	43	38
2.6	30	27	23	41	36	33	48	43	38	51	47	42
2.8	32	29	25	44	39	36	51	47	41	55	50	45
3.0	34	31	27	47	42	38	55	50	44	59	54	48
3.2	37	33	29	51	45	41	58	53	47	63	57	51
3.4	39	35	30	54	47	43	62	57	50	67	61	54
3.6	41	37	32	57	50	46	66	60	53	71	65	58
3.8	44	39	34	60	53	48	69	63	56	75	68	61
4.0	46	41	36	63	56	51	73	67	59	78	72	64
4.5	54	48	42	74	66	60	86	78	69	92	84	75
5.0	62	55	48	85	75	69	99	90	80	106	97	86
5.5	70	62	55	96	85	78	111	102	90	120	109	98
6.0	78	69	61	107	95	87	124	113	100	133	122	109
6.5	86	77	67	119	105	96	137	125	111	147	135	120
7.0	94	84	73	130	114	104	150	137	121	161	147	131

WATTS PER SQUARE FOOT

TABLE 5 - FOOTCANDLE LEVELS: FLUORESCENT FIXTURES (contd.)

FIXTURE	F5			F6			F7			F8		
RM FIN	LT	MED	DK	LT	MED	DK	LT	MED	DK	LT	MED	DK
0.2	2	2	2	8	7	6	5	3	1	2	2	2
0.4	4	4	3	15	15	13	10	6	3	4	3	3
0.6	6	6	5	23	22	19	15	9	4	5	5	5
0.8	9	8	7	31	30	26	20	12	6	7	7	6
1.0	11	10	9	39	37	32	28	15	7	9	8	8
1.2	13	12	10	46	44	38	30	18	9	11	10	9
1.4	15	14	12	54	52	45	36	21	10	12	12	11
1.6	17	15	14	62	59	51	41	24	12	14	13	12
1.8	19	17	15	70	67	58	46	27	13	16	15	14
2.0	22	19	17	77	74	64	51	31	14	18	17	15
2.2	24	21	19	85	81	70	56	34	16	20	18	17
2.4	26	23	20	93	89	77	61	37	17	21	20	18
2.6	28	25	22	100	96	83	66	40	19	23	22	20
2.8	30	27	24	108	103	89	71	43	20	25	24	21
3.0	32	29	26	116	111	96	76	46	22	27	25	23
3.2	35	31	27	124	118	102	81	49	23	28	27	24
3.4	37	33	29	131	126	109	86	52	24	30	29	26
3.6	39	35	31	139	133	115	91	55	26	32	30	27
3.8	41	37	32	147	140	121	97	58	27	34	32	29
4.0	43	39	34	155	148	128	102	61	29	35	34	30
4.5	51	45	40	182	174	150	119	72	34	42	39	35
5.0	58	52	46	209	200	173	137	82	39	48	45	41
5.5	66	59	52	236	225	195	155	93	44	54	51	46
6.0	73	66	58	263	251	217	173	104	49	60	57	51
6.5	81	73	64	290	277	240	191	115	54	67	63	57
7.0	89	79	70	317	303	262	208	125	59	73	69	62

WATTS PER SQUARE FOOT

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TABLE 6 - DELAMPING SCHEDULE FOR FLUORESCENT FIXTURES
(to result in light level of 30 footcandles)

LAMPS PER ROOM	EXISTING FOOTCANDLE LEVEL 35	40	45	50	55	60	65	70	75	80
2	0	1	1	1	1	1	1	1	1	1
4	1	1	1	2	2	2	2	2	2	3
6	1	2	2	2	3	3	3	3	4	4
8	1	2	3	3	4	4	4	5	5	5
10	1	3	3	4	5	5	5	6	6	6
12	2	3	4	5	5	6	6	7	7	8
14	2	4	5	6	6	7	8	8	8	9
16	2	4	5	6	7	8	9	9	10	10
18	3	5	6	7	8	9	10	10	11	11
20	3	5	7	8	9	10	11	11	12	13
22	3	6	7	9	10	11	12	13	13	14
24	3	6	8	10	11	12	13	14	14	15
26	4	7	9	10	12	13	14	15	16	16
28	4	7	9	11	13	14	15	16	17	18
30	4	8	10	12	14	15	16	17	18	19
32	5	8	11	13	15	16	17	18	19	20
34	5	9	11	14	15	17	18	19	20	21
36	5	9	12	14	16	18	19	21	22	23
38	5	10	13	15	17	19	20	22	23	24
40	6	10	13	16	18	20	22	23	24	25
42	6	11	14	17	19	21	23	24	25	26
44	6	11	15	18	20	22	24	25	26	28
46	7	12	15	18	21	23	25	26	28	29
48	7	12	16	19	22	24	26	27	29	30
50	7	13	17	20	23	25	27	29	30	31

appendix scheduling

HEATING

DETERMINE START-UP TIME

Find the lead times required for boiler start-up required to reach 68° F. for various temperatures.

1. Place one thermometer in a convenient location outside and another in a representative location inside (such as a classroom which gets particularly cold at night).

2. Record the following information for a period of 30 days (or more if required) on TABLE 7 - DAILY RECORD: BOILER START-UP AND SHUT-DOWN in the columns indicated.

- Outside and inside temperatures at start-up.
- Time of start-up.
- Time that the indoor thermometer reaches 68° F.
- The "lead time" required for each of these conditions. ("Lead time" refers to the time at which the inside thermometer reaches 68° F. minus the start-up time.)

3. Record the lead times required for inside and outside temperatures on TABLE 8 - LEAD TIMES ACCORDING TO TEMPERATURE: BOILER START-UP.

DETERMINE SHUT-DOWN TIME

Find the earliest boiler shut-down times for various temperatures which will maintain 68° F. in all occupied spaces.

1. Record the following information every day on

TABLE 7 - DAILY RECORD: BOILER START-UP AND SHUT-DOWN in the columns indicated.

- Outside temperature at shut-down.
- Time of shut-down.
- Time that the indoor temperature drops below 68° F.
- Lead time (time that the indoor temperature drops below 68° F. minus the shut-down time).

2. Shut down the boiler a bit earlier each day until the temperature on the indoor thermometer drops below 68° F. before the end of the school day. When this happens 15 minutes before the end of the day, add 15 minutes to the shut-down time used that day for future use for that temperature and record it on TABLE 9 - LEAD TIMES ACCORDING TO TEMPERATURE: BOILER SHUT-DOWN.

TABLE 7 - DAILY RECORD: BOILER START-UP AND SHUT-DOWN

DATE	START-UP					SHUT-DOWN			
	TEMPERATURE		TIME			TEMP	TIME		
	OUT-SIDE	IN-SIDE	START-UP	68°	LEAD	OUT-SIDE	SHUT-DOWN	68°	LEAD

TABLE 8 - LEAD TIMES ACCORDING TO TEMPERATURE: BOILER START-UP

		OUTSIDE TEMPERATURE									
		11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60
INSIDE TEMP	41-45										
	46-50										
	51-55										
	56-60										
	61-65										
	66-70										

TABLE 9 - LEAD TIMES ACCORDING TO TEMPERATURE: BOILER SHUT-DOWN

	OUTSIDE TEMPERATURE									
	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60
68										

VENTILATION

EXHAUST SYSTEMS

identify exhaust zones

1. Find the spaces served by each exhaust fan either from the design drawings or by turning on one fan at a time and checking from room to room to find which spaces are being exhausted. In some buildings the exhaust systems are straightforward and this will be easy. In others, it may be necessary to have specially trained people make the determinations. If this is required, contact the Borough Supervisor's Office of the Bureau of Plant Operation.

2. Fill in TABLE 10, ROOMS SERVED BY EXHAUST FANS: EXHAUST ZONES. First, list the identification number of each fan in the building and then the room number of each space served by each space served by each fan. This will then indicate the "exhaust zones." (Note that in some cases a single room may be served by more than one exhaust fan.)

develop program for use and non-use of fans

1. Determine the times of day when an "exhaust zone" is not in use. When a fan serves a single large space such as a gymnasium or shop, this is not a problem. When a fan serves several classrooms, however, it may be more difficult. Using TABLE 11- ROOM USE SCHEDULE FOR EXHAUST FAN NO. XX, identify the exhaust fan at the top of the table and then list all room numbers served by that fan. Use one copy of TABLE 11 for each fan (Note: One copy has been provided; make additional copies as required.)

2. Using the partially completed copies of TABLE 11, ask the administrative person responsible for scheduling the use of rooms to check off on the TABLES each period when each room is in use and return the completed TABLES to you.

3. Record the periods when each fan must be in operation in the column titled OPERATION.

4. Complete TABLE 12 - OPERATING SCHEDULE FOR EXHAUST FANS. Transfer the fan number and periods of operation for each exhaust fan (from all copies of TABLE 11) to TABLE 12 and fill in the spaces corresponding to the times when operation of the fans is required. At all other times the fans can be left off.

Note: It may not be possible to shut off a fan whenever a space is not occupied because of lack of manpower available. If this is the case, control the fans for those periods when several fans can be deactivated at one time.

INDIRECT AIR SYSTEMS

TABLE 13 - ROOMS SERVED BY INDIRECT HEATING UNITS; TABLE 14 - ROOM USE SCHEDULE FOR INDIRECT HEATING UNIT NO. XX, and TABLE 15 - OPERATING SCHEDULE FOR INDIRECT HEATING UNITS correspond for indirect air systems to TABLES 10, 11, and 12 for exhaust systems. Follow the same process of investigation and recording of information to complete the TABLES and develop a schedule to operate the indirect air systems only when required according to the use of the spaces they serve. (See instructions for TABLES 10, 11, and 12.

SUMMARY

The completed TABLE 12 and TABLE 15 will indicate the full operating schedule for fans in a building to permit the greatest energy saving through the elimination of unnecessary fan use.

TABLE 10 - ROOMS SERVED BY EXHAUST FANS: EXHAUST ZONES

EXHAUST FAN NUMBER	ROOMS SERVED																							
F_																								
F_																								
F_																								
F_																								
F_																								
F_																								
F_																								
F_																								
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F_																								
F_																								

TABLE 11 - ROOM USE SCHEDULE FOR EXHAUST FAN NO.

DAY	PERIOD	ROOMS SERVED																							OPERATION
SUN																									
SAT																									
FRIDAY																									
THURSDAY																									
WEDNESDAY																									
TUESDAY																									
MONDAY																									

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TABLE 12 - OPERATING SCHEDULE FOR EXHAUST FANS

FAN NO.

DAY	PERIOD																								
SUN																									
SAT																									
FRIDAY																									
THURSDAY																									
WEDNESDAY																									
TUESDAY																									
MONDAY																									

TABLE 13 - ROOMS SERVED BY INDIRECT HEATING UNITS

INDIRECT HEATING UNIT NUMBER	ROOMS SERVED																							
U-																								
U-																								
U-																								
U-																								
U-																								
U-																								
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U-																								

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TABLE 14 - ROOM USE SCHEDULE FOR INDIRECT HEATING UNIT NO.

ROOMS SERVED

DAY	PERIOD																							OPERATION
SUN																								
SAT																								
FRIDAY																								
THURSDAY																								
WEDNESDAY																								
TUESDAY																								
MONDAY																								

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TABLE 15 - OPERATING SCHEDULE FOR INDIRECT HEATING UNITS

UNIT NO.

DAY	PERIOD																								
SUN																									
SAT																									
FRIDAY																									
THURSDAY																									
WEDNESDAY																									
TUESDAY																									
MONDAY																									